LIME AND MARL:

THEIR

AGRICULTURAL USES.

WITH

EXPLANATIONS OF THEIR PROPERTIES AND MANAGEMENT, THE SOILS TO WHICH THEY ARE APPLICABLE, AND THE PRECAUTIONS TO BE OBSERVED IN THEIR USE.

ESPECIALLY ADAPTED TO THE WANTS OF PRACTICAL FARMERS.

BY JAMES HYATT,

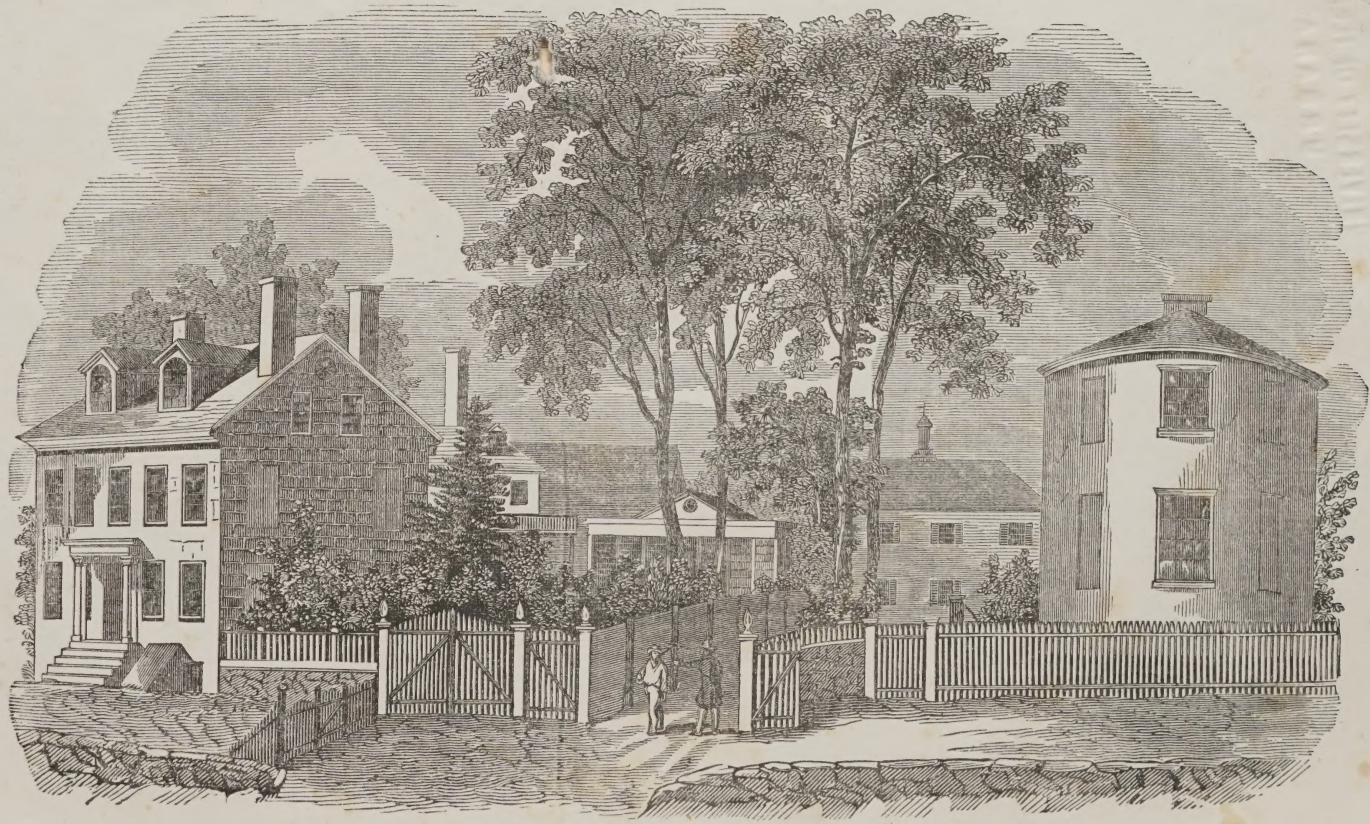
CHEMIST OF THE MOUNT AIRY AGRICULTURAL INSTITUTE, GERMANTOWN, PA.

PRINTED FOR THE INSTITUTE,

And for sale by J. W. Moore, 193 Chestnut Street, Philadelphia; Clark & Austin, 205 Broadway, New York; and at Bookstores and Agricultural Warehouses generally.

Price 12½ Cents.

1848.



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T. K. AND P. G. COLLINS, PRINTERS.

PREFACE.

No single substance, perhaps, has more extensively engaged the attention of farmers, as a means of improving their soils, than lime, including that admixture of it called marl; and while it has, in many instances, fulfilled the high expectations that have been entertained of its beneficial effects, in other cases it has either signally failed, or proved decidedly injurious. And it cannot be denied, that, in general, much of the advantage which might have resulted from its use, has been lost, from the want of a correct understanding of the economy of its application.

Although the effects of lime are in some respects *mechanical*, so that a portion of its influences are such as are derived from a change in the *texture* of the soil, yet its principal office is to act *chemically* upon various ingredients in soils; and, therefore, a knowledge of its chemical properties is indispensable to its judicious management.

The exhaustion of soils by the use of lime, and the unfavorable results from the injudicious use of lime in a caustic state, having produced, with many, a distrust of its valuable properties, it is desirable that the means of avoiding such effects, without losing the advantages to be gained by its proper use, should be generally understood.

It has been with a view to give greater publicity to those facts and principles which, indicated by theory, have been thoroughly tried and established by practice, that the writer has consented to undertake a task, which, although it may entitle him to little credit, in the field of originality, may at least show his disposition to be useful, in the dissemination of that knowledge of which,

heretofore, the great farming interest has been in some degree deprived.

In order to obtain the information necessary to a complete understanding of the properties of lime, and to an enlightened and judicious application of it to the soil, it has been necessary to procure extended treatises on agriculture or on manures, from which, what facts they contained, generally quite incomplete, could only be gleaned by much labor and care; so that such information has been, for the most part, where it was not to be had by all.

Whatever more attainable publications have been issued, have either been in such a shape as not to have obtained general attention, or the time that has elapsed, and the improvements that have been made, since their publication, have detracted somewhat from their value. The observations on lime, made in our agricultural journals, are so much scattered through the different numbers, and even if collected, are wanting in so many particulars, and need so much arrangement, as to form a serious obstacle to one desirous of knowing all that should be known on this subject.

It has been thought, therefore, that a treatise, in which everything essential should be embodied, in a form requiring no tiresome search, and the cost of which should be no impediment to its general perusal, might be of service to the Agricultural world.

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THE

AGRICULTURAL USES

OF

LIME AND MARL.

INTRODUCTORY REMARKS.

In view of the great importance of lime in Agriculture, of the gross errors often committed in its use, and of the general benefits to be obtained by its right application, the writer of this treatise will endeavor to point out the circumstances in connection with which it may be judiciously applied, as well as to refer to those in which it will be useless or hurtful. He proposes, also, to attempt an explanation of the mode of its action, the reasons of its usefulness, and the natural and artificial sources of its supply.

2. In order that this exposition might be correct, if possible, in every particular, so as to lead none into error, and that it should be entitled to the attention of practical men, everywhere, much labor and thought have been bestowed upon it. It will be found, perhaps, to consist, not of the experience of a single individual, nor of the speculations of a hasty theorist, but to embody the results of the observations of sound and successful farmers, in this and in other countries, and to be in accordance, also, with the true principles of Agricultural Chemistry.

3. And as to be useful, this exposition must be brief, it has been thought advisable to omit statements of actual results, and particular cases, confining the observation to those general principles that are well established, and that, taking modifying circumstances in account, are worthy of universal adoption.

4. Fortunately, the testimonies in regard to the use of lime, are most complete and harmonious;—the proofs are abundant, and are not at variance with each other.

5. It must be anticipated that very little of what is new, or original, can be introduced into this essay, for the subject has occupied the attention of both theoretical and practical men for so long a time, and to such an extent, that the chief labor of the writer has consisted, rather in collecting, comparing, and arranging facts, from a variety of sources, than in making observations and experiments. He thinks it sufficient to mention, that, having the opportunities, he has freely availed himself of the experience and investigations of those who have interested themselves in Agriculture, in this country and in Europe.

CHAPTER I.

THE COMPOSITION AND PROPERTIES OF LIME.

6. Lime is composed of two simple bodies, of which one is a shining white metal called *Calcium*, and the other is a gas, existing abundantly in both air and water. This gas is called *Oxygen*.

7. Lime, therefore, is a compound of calcium and oxygen, called *Oxide of Calcium*. And as chemists have found that calcium may be artificially combined with twice the proportion of oxygen that is invariably found in lime, they partially distinguish between these two oxides, by calling lime *Protoxide of Calcium*, that is, *the first oxide*.

8. Lime is well known to be obtained by heating limestone, marble, chalk, shells, etc., to a very high bright red heat. These substances are chiefly composed of lime, united with carbonic acid; and the heat merely drives off the acid in the form of gas. Obtained thus, freshly burned, lime is often called *quicklime*, and is pure if obtained from pure white marble; otherwise it contains variable proportions of other substances, such as flint, oxide of iron, magnesia, etc.

9. Lime possesses, though in an inferior degree, the distinctive chemical properties of potash and soda; that is, it has a biting, or burning taste, and changes vegetable blue colors to a green, so that it is an alkaline substance.

10. The attraction of lime for water and for acids is very powerful; for on being exposed to the atmosphere, though in

large lumps, it attracts about one-third of its own weight of water, and spontaneously slacks, or is converted into what is called a *hydrate*, a fine dry powder.

11. When the lime is thus combined with water, the carbonic acid of the air acts upon it, and rapidly driving off one-half of the water and taking its place, diminishes the caustic property of the lime, and renders it somewhat mild, adding still more to its weight.

12. After this, the same action continues, though very slowly, until the carbonic acid has expelled all the water, and the lime has entirely lost its caustic property, and is rendered mild carbonate of lime, being in the same condition in which it was before being burned, except that it is in powder. It is now about one and three-fourths times as heavy as when taken from the kiln, and its bulk is also much increased, being often more than doubled. (See *note* A.)

13. What ordinarily goes by the name of *lime*, may, therefore, be in any one of the four following states. 1st. Unslacked lime, quicklime, or that freshly burned. 2d. Caustic lime, or hydrate of lime,—such as is obtained by slacking quicklime with water. 3d. Air slacked lime, which is generally partly a hydrate, and partly a carbonate. 4th. Carbonate of lime, or that which has become fully mild by the absorption of carbonic acid, and possesses no caustic nor alkaline property.

14. The word *lime correctly used*, means that which is called quicklime, in its pure and fresh state.

15. Lime possesses an attraction not only for carbonic acid, but for acids generally, and is found in nature combined with sulphuric, nitric, phosphoric, silicic, oxalic, and other acids. Lime united with sulphuric acid and water, constitutes gypsum, or plaster; and with phosphoric acid it forms the earthy part of bones, a phosphate of lime.

16. Almost all acids, including common vinegar, are capable of driving off carbonic acid from carbonate of lime. They then take its place. This furnishes one method of detecting the presence of carbonate of lime in soils, for by pouring vinegar, or some other dilute acid upon the suspected substance, if carbonic acid be present it will be set free, giving rise to an effervescence or foaming, such as we see in a glass of soda-water. As carbonic acid is not often considerably combined with any other

substance than lime, in soils, the foaming is usually a reliable proof of the presence of carbonate of lime. (See *note* B.)

17. The hydrate of lime requires nearly eight hundred times its weight of water at the temperature of 60° to dissolve it, and still more at higher temperatures. Mild carbonate of lime requires more than ten thousand times its weight of pure water to dissolve it. But if the water contain carbonic acid, as is generally the case with spring water, the limestone or carbonate dissolves more freely.*

18. Marl contains from ten to ninety per cent. of carbonate of lime or mild lime, with variable proportions of sand, clay, and animal, vegetable, and other matter. It is a substance which greatly varies in its appearance and properties. It is often an earthy matter that, when dry, readily falls into powder. Its characteristic, however, is that it contains lime in the mild form.

19. When any substance is suspected to be marl, or to contain it, the matter may be determined by pouring vinegar, or some other dilute acid upon it, when if the effervescence or foaming, before mentioned, ensues, it may be considered that carbonate of lime is present.

20. It is proper to mention, however, that the term *marl* is sometimes used to denote any fertilizing earthy matter, and has been applied to a substance rich in potash, found in some localities, which is also a valuable manure; but the writer, in his use of the word, will consider marl to be a mixture of carbonate of lime with other substances, as first explained.

21. The value of any specimen of marl may in general be estimated by the amount of the effervescence which ensues, on pouring vinegar or muriatic acid upon it; or may be more accurately determined by a chemical analysis, which shows the proportion of carbonate of lime, though; if the analysis show all the ingredients and their proportions, it is more useful. Marls frequently contain, also, a small proportion of phosphate of lime. Phosphates are highly useful in all soils, and add, therefore, to the value of the marl. Whatever *organic* matter, that is, whatever animal or vegetable substance, the marl contains, will, for most purposes, increase its value. The quantity of *organic* matter may be determined by burning the marl at a dull red heat. The loss in weight is the

* The sulphate of lime, or gypsum, is soluble in 430 times its weight of water, at common temperatures.

weight of the organic matter; for *organic matter* is that which, having been deposited by some plant or animal, disappears again, or goes off in the form of gas, when burned. The admixture of sand or clay in marl, may add to its value or not, according as these substances prevail in the soil to which the marl is to be applied.

CHAPTER II.

OF THE SOILS ON WHICH LIME IS USEFUL.

22. *Lime may be advantageously applied, in proper quantities, and under proper circumstances, to all soils, except to marly and calcareous ones*, that is, except to those which already contain upwards of 5 or 6 per cent. of carbonate of lime, and in certain cases, even, to some of these.

23. The lands which lime benefits in the greatest degree are the following:

Peaty soils and those which contain large quantities of vegetable matter;

Clayey soils which are needed to be rendered more light, open, and active;

Lands that are worn out by long and exhausting culture;

Soils sterile from the existence of green copperas (proto-sulphate of iron), in considerable quantities;

Soils wanting potash;

And those which are found to be deficient in the quantity of lime necessary for its supply to the growing crops.

On other soils, lime may often be profitably employed according to their mechanical condition and chemical composition, and to the expense of liming; as will be hereafter explained.

24. Those soils which contain a proper proportion of the different other mineral ingredients necessary to fertility, together with sufficient organic matter, and which are of the right mechanical structure, as to mellowness, being neither too compact nor too open, may need no application of lime, for a long series of years, although the percentage of lime in them is very small. Chemical analyses have shown, that soils known to be fertile without

manures,* may contain no more than one five-hundredth part of lime: for then, though the proportion of lime is inconsiderable, yet we learn by calculation that an acre of soil, six inches in depth, will contain about a ton and a half of lime, undoubtedly more than sufficient for the supply of rotations of crops for a quarter of a century.

25. These fertile soils, however, which contain such small, and even somewhat larger proportions of lime, may doubtless be made to yield larger and surer crops, by its addition in considerable quantities. The effects of lime on such soils are, with proper management, altogether beneficial, notwithstanding that they then require, besides the expense of liming, a more costly system of manuring. The increased production that follows the liming tends to exhaust the soil of its necessary ingredients, (see *note* C,) and to destroy its fertile properties, so that while lime is continued to be applied, instead of supplying the place of other manures, it becomes necessary to be more liberal in their application. The farmer who increases his crops, without increasing his manures, will soon render his soil barren.

26. All this extra labor and expense, however, will be amply repaid by the gain in production; for if there is any profit in raising a light or a medium crop, on a piece of land, this profit rapidly swells, as the same land is made to yield its heavier products.—It would not be advisable that time and money should be lavished in the injudicious and extravagant application of manures. That which a farm is capable of yielding in the shape of animal and vegetable manures, should be carefully husbanded, as well as that which can be economically purchased and applied.—And foreign substances in the shape of ashes, plaster, bone-dust, or salt, of which the land may stand in absolute want, must be procured. With care and good judgment, in these matters, such a soil as is referred to, may be limed with great advantage.

* By *manure* is meant any substance whatever added to a soil to increase its fertility.

CHAPTER III.

THE QUANTITY OF LIME TO BE APPLIED.

27. On clayey and peaty soils, the application may be very liberal: indeed little benefit is to be expected from the use of lime on such soils, except in large quantities. From one hundred to one thousand bushels an acre are used; and on these soils, there is little to be feared from an over application.

28. On worn out lands, from ten to fifty bushels an acre, is a sufficient quantity, and when the amount intended to be applied, is nearer the larger of the above proportions, it is better that the application should be divided into smaller parts, and repeated at intervals, in the course of the rotation, or between the rotations. On exhausted soils, particularly, it is necessary to see that there is no deficiency in the organic elements, and to supply any such deficiency in connection with the liming.

29. When a soil possesses every requisite of fertility, except that lime is wanting, a first application of ten bushels to the acre, and subsequent ones at the rate of two or three bushels an acre, annually, are sufficient to supply the original want, and to furnish as much to the soil as is taken off by the crops.

30. Applied at this rate of two or three bushels to an acre a year, *the quantity of lime necessary to the fertility of a soil*, will be supplied, with ordinary systems of rotation. But if those crops only are cultivated which tend most to exhaust the lime of a soil, greater quantities must be applied. Thus roots, as potatoes, turnips, beets, &c., and clover, all in an eminent degree, as well as grasses generally, exhaust the lime to a greater extent, and require more plentiful applications.

31. The chemical condition of the lime is, however, always to be considered, in determining the amount to be applied. When slacked suddenly and used immediately, in the caustic state, smaller quantities are required than those mentioned in this treatise; while if the lime has lain for many months, thoroughly exposed to the air so as to be entirely mild and carbonated, larger quantities may safely be used.

32. When it is intended, by a liberal system of farming, to

procure large and sure returns, and where lime or marl is to be had at a moderate expense, medium quantities, say five to fifteen bushels an acre, annually; that is, twenty to sixty bushels an acre, for each rotation of four years, may be applied, with great advantage, to soils already quite fertile, taking care that the animal and vegetable portion of the soil is maintained undiminished, by ploughing in green crops, or by alternating the applications of lime with those of yard, or other organic manure. But, as common systems of cropping do not take as much lime from the soil, as the larger of the above proportions would furnish, a time will arrive, after a number of rotations, when the soil will be filled with lime to such an extent, that the further use of it would be either of no avail, or decidedly hurtful. There can be no utility in the application of lime to a soil which already contains twelve or fourteen per cent.

33. The length of time before the soil will become saturated, will depend, not only on the extent of the limings, and on the nature of the crops, but also on the texture of the soil and subsoil. A retentive texture will not permit the fine particles of lime so readily to fall through it, nor will it allow of so great a waste, by the solution and washing out of the lime.

34. In the application of marl, we are to be guided by the proportions of its ingredients. Leaving out of view the sand or clay, of the usefulness of which on his soils every intelligent farmer is competent to judge, we have only to determine the proportion of carbonate of lime in the marl, and then to apply so much as will furnish the desired quantity of this ingredient. Should the organic matter of the marl be considerable, larger quantities may be applied on such soils as would be benefited both by lime and by animal and vegetable matter.

CHAPTER IV.

FREQUENCY OF THE APPLICATIONS.

35. All experience has shown smaller and oftener repeated applications, to be, by far, the most economical. The reasons are, that the large quantities which are necessarily applied when

the intervals are long, are more likely to be injurious, and also, that much of the effect of these is lost before it can be felt by the crops, from its sinking through the soil, either in the solid state, or dissolved by water. The economy of the custom, even, which prevails in some countries, to apply heavy limings at long intervals, so that a tenant may be able to avail himself of the full effect, until quite spent, of a liming made at the commencement of his lease, is very questionable.

36. The expense of applying a given quantity, will of course be less, if the whole be applied at once, instead of in divided portions, at successive times; and this, together with the consequent inconvenience, will, for the most part, prevent annual limings. An application once in each rotation, will generally be found most judicious.

CHAPTER V.

THE PREPARATION OF THE LIME, AND THE STATE IN WHICH IT SHOULD BE APPLIED.

37. Lime should be applied in the finest possible state of division, and under such circumstances as to be maintained in this condition.

38. Where it is to be applied in the mild form, it may, in some locations, be more economically procured in this form, by crushing and grinding limestone, chalk, shells, &c. This method may be preferred where fuel for burning is expensive, and power for crushing is more available. Calcareous shells and coral sands, which occasionally occur, are suitable for direct application.

39. Marls in general, need to be drawn out and exposed, so as to be dried, and often, by the action of the weather to be pulverized, before being spread. Many marls do not become sufficiently pulverized until both the heat of summer and the frosts of winter have acted upon them.

40. But where fuel is abundant, limestone, shells, etc., may be more conveniently prepared for pulverization by burning.*

* When limestone containing much flint is used, it is liable to be *over-burned* by too high a temperature, so as to be rendered inactive.

The subsequent slacking, or combination of the quicklime with water, to form the hydrate, may be accomplished either by exposure to the atmosphere, or by the direct application of water; the latter method being preferable, only when it is desired, by the rapidity of the process, to prevent the recombination of the lime with carbonic acid, so as to obtain and apply it in its hot or caustic state. Spontaneous slacking is less troublesome, and, except in the case just mentioned, equally advantageous.

When slacked by exposure to the atmosphere, though examined immediately after the lumps have completely fallen into powder, the lime will be found carbonated to a very considerable extent.

41. When slacked by the direct method, in the more rapid way, the water should be applied very gradually, otherwise there will be many small lumps, and the process will be neither so rapid nor so complete.

42. Care should also be taken that the quantity of water used be not so great as to bring the slacked lime, or hydrate, to the state of a paste; enough only being applied to complete the slacking, and to reduce the lime to fine dry powder. The amount of water required is, what will weigh about one-third as much as the lime. (See *note* A.) If used in a wet state, lime is liable to unite with substances in the soil, and form a mass that sets, and becomes hard like mortar. It is evident, that inattention to these particulars may diminish the benefits to be expected, or may result in positive injury.

43. As to the question whether lime should be used in its caustic or in its mild form, it may be observed, that caustic lime is preferable only on soils where there is too great an abundance of inactive vegetable matter, and on those in which organic manure lies unchanged and ineffective; the partially mild lime, obtained by spontaneous slacking, being equally useful in all other cases, for this certainly, if applied soon after being slacked, still contains enough caustic lime to produce all such effects as may be thought necessary.

44. Indeed, it is generaly admitted that pulverized chalk, or burned lime which has become fully carbonated, is, in all cases, except in the above, equally effective and scarcely more slow in its action. Mild lime is also less liable to injure either the texture of the soil, or its chemical properties, while it does not exhaust to

the extent that caustic lime does, by causing a greater loss of vegetable matter than is required or taken up by the growing crops.

45. The more rapid and more effective action of caustic lime may well be questioned, in view of the observed fact that the results of its application are seldom seen the first year, so that before this influence is exerted, it probably has time to become fully mild.

46. It is true, that the expense of applying the quantity requisite to produce a given effect may be something less, if applied in the caustic state, because, when fully carbonated, it is about one-fifth heavier than the same amount of lime, in the form of hydrate. This difference, however, is not so great as it has generally been estimated, for the carbonate has erroneously been compared with *unslacked lime*, a form in which it is never advisable that lime should be applied.

47. The only cases in which it is necessary to take into account the really considerable difference, both in bulk and in weight, between unslacked lime and the carbonate (See *note* A). are in the purchase, and in carting from the kiln. Unslacked lime, pound for pound, or bushel for bushel, is really worth a great deal more than the fully carbonated, or even than the recently air-slacked article; so that, if sold at the same price, the lime burners would make a large profit, by allowing their lime to be exposed to the air, and the purchaser would waste his money in buying and carting gas and vapor, which he could have in abundance at home, for nothing.

48. The trifling saving in the mere application of pure caustic lime, would not compensate for its injurious tendencies, on all soils, except on the peaty, the mucky, on those exceedingly rich in vegetable matter, and on those in which yard manure lies inactive. In fact, unless there is so much organic matter that it becomes desirable to dissipate it, the application of completely carbonated lime is generally more safe and judicious, while the use of lime, as soon as it can be air-slacked, especially in a moist atmosphere, being then still somewhat caustic, will be about as effective in all cases, and in most be altogether preferable to the use of caustic lime. Besides, caustic lime should not be used in contact with seeds or herbage. On clays, also, the use of caustic lime must tend rather to injure than to improve the

texture of the soil; with carbonate of lime there is not the same liability to the formation of a mortar that cakes and hardens.

49. By composting lime with five or six times its bulk of earth, a considerable saving may generally be made, particularly where lime is expensive. The more complete manner in which it may afterwards be incorporated with the soil, renders a smaller quantity equally efficacious. This composting is no doubt always best, except on peats, and is greatly preferable on light sandy soils, in which the use of lime might otherwise prove of little avail.

50. Although it may seem to conflict with the theory of a celebrated chemist, it must, nevertheless, be said that both science and judicious practice tell us, that the use of lime which is at all caustic, in compost heaps, in connection with animal and vegetable matter, and especially in composts of yard manure and urine, is decidedly injurious. He who desires to husband his resources, and to have early matured, and large crops of grain, or seeds of any kind, should not mix caustic lime, *either in the compost heap, or in the soil*, with yard manure, urine, guano, night-soil, or with any manure containing nitrogen; for it is well known that caustic lime expels ammonia (the form which nitrogen generally takes in these manures) from its combinations.

51. This objection does not apply to lime that is completely carbonated, but as air-slacked lime does not become entirely carbonated, without long exposure, much care is requisite in this matter, unless, indeed, means be used, as is sometimes done, to prevent the escape of whatever ammonia may be liberated. A covering for the compost heap of moist muck, or clayey soil, or the incorporation of these substances in the heap, may serve this purpose to a greater or less extent, whenever it is determined to use caustic lime.

52. Still the decomposition of organic matter, for which, alone, caustic lime need be used in the compost heap, may be produced in other ways, and particularly by fermentation. Thus the liability to loss of the ammonia, may be avoided.

53. Even the use of such fixers of ammonia as gypsum and copperas, cannot be depended upon in connection with caustic lime, though these agents are quite reliable under other circumstances. In the muck heap, besides, carbonate of lime is just as effective for neutralizing such vegetable acids as are likely to be

injuriously present. Here, therefore, caustic lime need not be employed.

54. There are still other objections to the use of lime in a caustic state. The hydrate of lime being about thirteen times more soluble than the carbonate, there is greater liability to its loss by washing out, from the action of water, and heavy rains; while the small proportion of carbonic acid present in the moisture of a soil, dissolves both hydrate and carbonate, to a sufficient extent to furnish plants with their lime. The fact that carbonic acid is less abundant in the heavy rains which are more liable to result injuriously, gives additional force to the opinion, that caustic lime is more liable to waste than that which is mild.

CHAPTER VI.

MODE OF APPLICATION AND STATE OF THE SOIL.

55. When the quantity applied is quite small, broadcast sowing is most common, but with larger proportions, shoveling from the cart, or depositing in heaps and subsequent spreading, is resorted to. The plan of drawing the unslacked lime out on the land, and depositing it in small heaps to slack, is not considered as profitable as previous slacking.

56. Inasmuch as the equal distribution of the lime is a very essential matter, and as the sowing and spreading are both laborious and unpleasant, the use of a machine for these purposes, becomes a matter not only of convenience, but of great economy. There can be no less troublesome means of distributing the lime, and none so effectual in securing a uniform application, in any desired proportion.

57. There is no doubt that lime should be kept on, or near the surface, so that whatever ploughing or harrowing is resorted to in order to incorporate it with the soil, should be as shallow as possible. The beneficial effects of lime depend very considerably on the assistance which is rendered by the carbonic acid of the atmosphere, and of the light rains, and besides, lime sinks downward, by being dissolved, and from the fineness of its division, by all movements of the particles of the soil produced by the

stirring of implements and rains. We may therefore calculate that it will produce all desirable effects below the surface, though not deeply incorporated with the soil.

58. When, however, lime is cheap, the application is large, there is vegetable matter to be decomposed and acids to be neutralized, and when more rapid effects are desired, such a concurrence of circumstances would warrant a more deep incorporation, though even then it should not be wholly turned from the surface.

59. On pastures, lime is sown, or very thinly spread; on fallows, but more especially in large quantities on peaty soils and stiff clays, it may be applied before breaking up with the plough; but on cultivated fertile soils, the smaller application commonly made, is best applied immediately before the last harrowing.

CHAPTER VII.

PRECAUTIONS IN THE USE OF LIME.

Many of the facts belonging under this head have been before referred to; but it may be advisable that the whole should be here included.

60. Highly caustic lime should not be introduced into direct contact with seed, in the hill or drill.

61. Caustic lime should not be applied with yard manure, nor with any of the before-mentioned manures which contain nitrogen. Very coarse unfermented matter is not so liable to be injured by it, especially if covered with earth or muck, so that the liberated gases may be absorbed.

62. Lime should not be used in a wet state; nor should water be too rapidly applied in slacking it.

63. Unslacked lime should not be applied.

64. On wet lands, unless the liming is preceded by draining, little benefit can be expected.

65. Care should be taken to maintain a sufficient amount of organic matter in the soil, for liberal liming and cropping would otherwise render it barren.

66. It must be borne in mind that lime can never supply the

place of other manures. It cannot furnish sulphuric acid like gypsum, nor phosphoric acid like bones, guano, yard manure, and some marls, nor chlorine and sodium like common salt. Lime may assist to set potash free from substances in the soil, but where there is no potash, it cannot furnish it like ashes.

67. As its action is not immediate, whenever it is desired that lime shall affect a particular crop, it should be applied at least a year previous.

68. The liming of shallow, of dry, and of light sandy soils should be very moderate. Small applications only are required, or are advantageous on worn out soils, as well as on fertile ones.

69. The presence of magnesia, in any considerable quantity, being considered unfavorable to vegetation, and more especially in connection with lime, care must be observed that the lime is not obtained from magnesian limestone. (See *note* D.)

70. Clayey marls are best on sandy soils, and sandy marls on clays. The contrary course may sometimes be injurious, as well as the excessive use of any marl.

71. As lime is thought to injure the strength of the fibre of flax, it should not be applied so as to unfavorably affect this crop.

CHAPTER VIII.

BENEFICIAL EFFECTS OF LIME, AND THE MANNER OF ITS OPERATION.

72. Lime acts both mechanically and chemically: mechanically, from its loose open nature, it renders clayey and heavy soils more light, diminishes their tenacity, assists the passage of water through them, and thus renders their tillage less difficult; its other effects are mostly chemical.

73. Lime being so universally found in the ashes of plants, we must conclude that it is necessary to their healthy growth, and therefore, if absent, or nearly so, in soils, it must be supplied.

74. It assists the decomposition of organic matter, and is, therefore, beneficial where this matter is abundant or inert. The rotting of sward turned in, and of bogs, is considered to be promoted by caustic lime. By undergoing this decomposition, organic matter is converted into food for plants.

75. It neutralizes, and combines with the acids which are injurious in soils, and especially abundant in peats and mucks. In combination with some of these acids, it is more soluble, and is, therefore, more readily taken up to supply the wants of plants.

76. When it combines with these acids, it yields up its carbonic acid, which may be absorbed by roots, and thus the growth of the crop may be materially promoted. These compounds of lime with vegetable acids may be gradually decomposed, so as to furnish further food for plants, while the lime again takes the form of carbonate, and thus runs a perpetual round of usefulness.

77. Lime is capable of converting oxalate of potash or salt of sorrel, into insoluble oxalate of lime, and may thus prevent the growth of sorrel.

78. Green copperas, or proto-sulphate of iron, which is present in some soils, materially impairing their fertility, is decomposed by lime, gypsum being formed, and the iron becoming peroxidized, is made useful, instead of remaining hurtful. A similar decomposition of sulphate of magnesia and sulphate of alumina is advantageously promoted by lime.

79. From its effects on the vegetable acids, and on other deleterious substances, which are often present in subsoils, and in those brought for the first time under cultivation, the application of lime to these is generally found highly advantageous.

80. The application of caustic lime may sometimes assist in the destruction of insects.

81. Lime may be expected to benefit potatoes, turnips and red clover, which require larger quantities of it. Potatoes are rendered more mealy by liming. The tops, which contain the largest proportion of the lime, should not be wasted.

82. It is acknowledged that lime improves the quality of the grain crops, so that the seed is thinner skinned, and furnishes more and better flour. The crops of peas and beans are benefited both in quantity and quality. It diminishes the tendency to the formation of too much straw, assists to give inflexibility to the straw, so that the crop will stand more firmly, and by tending to prevent the formation of rust and fungus, diminishes the unfavorable effects of wet seasons.

83. According to the most reliable experience, lime, on many pasture lands, improves the quality both of the grasses and of the products of the dairy. The butter and cheese are better, and it

is admitted that the stock feeding on limed pastures, is improved in health and general condition; though caustic lime may often be injurious, and especially to young stock.

84. The application of lime to composts of muck and of vegetable matter generally, will have an excellent effect; but mild lime is preferable for this purpose, especially when matters containing nitrogen are added to the heap. Whatever may be the quantity of ammonia, either in the soil or in the atmosphere, it is not so great that we must drive it out of our manure heaps by the use of caustic lime. We need not fear an undue proportion of this most necessary aliment of cultivated crops, but should rather endeavor, particularly as it costs no considerable labor, to husband this, as well as all other substances that are capable of assisting the growth of plants.

CHAPTER IX.

THE SOURCES OF LIME, AND THE SOILS WHICH NATURALLY CONTAIN IT, OR ARE DEFICIENT.

85. That marl, shell sand, chalk, shells, limestone, marble and coral, contain lime, and are both the natural and artificial sources of it, is well known.* Soils associated with limestone rocks, frequently contain a considerable portion of lime; but it has been noticed that, though resting upon limestone or chalk, or even abounding in shells, or in loose masses or pebbles of limestone, they are sometimes almost totally destitute of lime in such a form as to be useful, that is, in a fine state of division.

86. This, doubtless, is accounted for by supposing the soil to have been derived from other sources than these rocks, and from the fact, that the firm texture of the shells or pebbles has, as yet, prevented their crumbling so as to form a part of the available soil. Hence, it often arises that liming proves advantageous on what are called limestone lands.

87. Besides these enumerated sources, known to be abundant

* The sea shore, and lands adjoining, in some localities, abound in a shell or a coral sand, which being rich in carbonate of lime, is a valuable manure.

in lime, there are rocks which, without being principally composed of it, yet contain it in considerable quantities, while there are others in which it is entirely wanting.

88. The granitic rocks, including gneiss and mica slate, are either destitute of lime, or contain it in very small proportions. Soils derived from these rocks will, therefore, contain little lime, and be capable of improvement by larger or smaller quantities, according as clay or sand may predominate in them.

89. The sienitic rocks, often included among the granites, contain a somewhat larger proportion of lime, and the derived soils will be of similar composition. On these soils, doubtless, lime may generally be employed with advantage.

90. Greenstone rocks and soils contain a more liberal proportion of lime, and stand in less need of its application. In some, this proportion is probably sufficient.

91. The serpentine rocks furnish little or no lime to the soils which are derived from them ; liming is, therefore, indispensable with these soils.

92. The slates and sandstone vary so much in their composition, that no general rules can here be given that will indicate, with much certainty, the proportion of lime in soils derived from them ; some are destitute of lime, while others contain considerable proportions.

A knowledge of the principles of mineralogy and geology will greatly assist the farmer in judging of the constituents and properties of soils, from knowing those of the rocks with which they are associated ; while the same knowledge will show him that it is necessary, when forming his opinion from geological and mineralogical data, to consider whether the soil has been derived from the surrounding or underlying rocks, or whether it is a drift from some other locality, and of a different origin.

93. There are also minerals which contain lime, though not in the form of carbonate, but combined with other acids. And the lime of sienitic rocks is in combination with silicic acid, called flint, constituting silicate of lime, while phosphate of lime exists in small proportions in all fertile soils. Sulphate of lime also, known as gypsum, or plaster, is extensively used in many districts. Chloride of calcium, as well as the fluoride, are natural substances, which, though containing no lime, have one of its elements, calcium, for their base, and this may, by natural causes,

be converted into lime. The nitrate of lime which exists to some extent, is also a valuable salt.

94. These substances may become the source of lime to plants, though they are to some extent incapable of the sort of influence exerted by carbonated or caustic lime, in assisting the decomposition of organic matter, in neutralizing vegetable acids, and in preparing, in the way that lime does, the food of plants. They may be looked upon, however, as highly useful substances, capable of supplying to some extent the want of lime in the other forms.

95. The existence of lime in soils, in combination with vegetable acids, has been referred to, as well as the important purposes which it then serves. These organic compounds of lime are dependent somewhat on the pre-existence of caustic lime or the carbonate. In the application of lime to muck, they are generally formed in considerable quantities.

96. Marls are for the most part formed from deposits of fresh water shells, in lakes and ponds, the animals having secreted the carbonate of lime of these shells from the water in which they lived. These ponds being formed from water passing through limestone, have derived their carbonate of lime from that source, as water impregnated with carbonic acid is a solvent of limestone. In some cases the water itself directly deposits the carbonate of lime. The shells, or the earthy matter containing them, are often afterward covered by a subsequent layer of peat or muck—or are more or less mingled with such vegetable matter as these ponds fill up into marshes. To swamps, then, and especially in the neighborhood of limestone rocks and ridges, we may look for deposits of marl.

97. Marls have doubtless sometimes been formed by the crumbling of rocks containing carbonate, or perhaps, silicate of lime. It therefore happens that marls are found in hill and mountain masses.

Marl, whenever it is abundant, as it requires neither crushing nor burning, generally affords the most economical means by which lime can be applied to soils. And as the lime in marl is not caustic, but mild, none of the precautions mentioned in regard to the use of caustic lime, need be observed with it; nor can those beneficial effects that only follow caustic lime be expected from marl.

Having now stated the most important facts connected with the

use of lime, the writer feels constrained to bring his remarks to a close. He has not thought it advisable to enter upon the details for determining the exact proportion of lime in soils.

Chemical analyses, though well worthy the attention of farmers, and though entered upon by some who take interest in such matters, will not be attempted, to much extent, by them. The scientific knowledge, the taste, the time, and the apparatus and chemicals, can never be generally possessed, while those who wish to engage in these investigations will find that works which treat solely on chemistry and chemical analyses, are not only more profitable than anything that could be included in this small treatise, but are absolutely indispensable to success.

Nevertheless, there is no species of knowledge that can be of more use to the farmer than chemistry. This science is connected with almost all agricultural operations, and the farmer is a practical chemist on a most extensive scale, but often, greatly to his loss, destitute of a knowledge of the chemical agents which he employs, and of the laws which govern their action. Every enterprising farmer, however, who entertains a just opinion of the value of scientific knowledge, will soon take such steps to secure its benefits, as will give him a great advantage over his more plodding neighbors. Inexpensive and easily understood books are to be had on all the sciences which interest the farmer. And so great now, are the facilities for obtaining such knowledge, that none, either young or old, need be destitute of it.

It is to be hoped that with the means now enjoyed, and likely still to be increased, the day is not far distant, when in our common schools, chemistry, mineralogy, geology, and botany, will be considered studies equally as necessary as reading, writing, and arithmetic; and when no person will be thought to have a common education, unless he understand the general principles of natural science.

NOTE A.

The equivalent or lowest combining proportion by weight of calcium is 20; that of oxygen is 8; of carbon 6; and of hydrogen is 1. Therefore the composition of lime and its compounds is as follows:—

20 parts by weight of calcium
8 " " oxygen, form
28 " " lime, or quicklime.

6 parts of carbon, and twice eight or
16 " oxygen, form
22 " carbonic acid. And

22 " carbonic acid unite with
28 " lime, and form
50 " carbonate of lime, or mild lime, which contains then only $\frac{28}{50}$ of pure lime. Also

8 " oxygen, united with
1 part of hydrogen, form
9 parts of water. And

9 " water unite with
28 " pure lime to form
37 " hydrate of lime, or caustic lime, containing $\frac{28}{37}$ parts of pure lime. These numbers, 9 of water and 28 of quicklime, represent the proper proportion of water for slacking, but as lime frequently contains impurities, $\frac{1}{3}$ of its weight of water, which is something less than the true proportion, will generally be sufficient, especially as we may depend upon the atmosphere to furnish any deficiency.

NOTE B.

It is no difficult matter for one who is ingenious, and has some knowledge of the principles of chemistry, to determine the proportion of lime in a soil. It is only necessary to digest a weighed portion in dilute muriatic acid, to add ammonia in slight excess to the clear solution, and then to precipitate the lime with oxalate of ammonia. The oxalate of lime may then be collected, dried, and weighed. According to the accuracy with which the process is managed, will the proportion of lime be determined.

NOTE C.

The simple elements, which are present in fertile soils, and which, in some of their forms of combination, may be considered necessary to the growth of plants, are the following:—potassium, sodium, calcium, magnesium, aluminum, iron, manganese, silicon, sulphur, phosphorus and chlorine. These are mostly combined with oxygen, when they form, respectively, potash, soda, lime, magnesia, alumina, oxide of iron, oxide of manganese, silicic acid, sulphuric acid, phosphoric acid, and chloric acid. The chlorine, however, instead of being combined with oxygen, is found united with some of the metals, forming chloride of potassium, chloride of sodium, or common salt, chloride of calcium, etc.

Besides these, plants require hydrogen, nitrogen and carbon, which are furnished to them, for the most part, in the respective forms of water, ammonia and carbonic acid, and which may be derived, either from the earth, or from the atmosphere.

NOTE D.

Magnesian limestones are generally of a yellow color, yet as some other limestones sometimes have the same hue, color does not serve to distinguish between them. A small proportion of magnesia, say one to three per cent., such as is often found in limestones, is not sufficient to be injurious. But when the proportion becomes as great as thirty-five to forty-five per cent., it gives to the lime the properties of a hydraulic cement, so that, in a wet state of the soil, it will harden, forming firm grains and lumps, and will remain in that condition, undergoing little change.

Besides, caustic magnesia never becomes completely carbonated by exposure to the air, and if slacked with water, it remains entirely caustic, and in this state it would undoubtedly be injurious to vegetation.

When the presence of magnesia is suspected in limestone, the matter may be determined by dissolving the limestone in dilute muriatic acid, and dropping clear lime water into the filtered solution. If the solution becomes turbid, by the formation of a white precipitate, magnesia is present, and using sufficient lime water to separate the magnesia, it will all fall in fine powder to the bottom. In this way, the proportion of magnesia may be roughly estimated.

This process of dissolving limestone in dilute cold muriatic acid, may also serve to show the proportion of silex, or flint, oxide of iron, and other insoluble matters in it. Whatever remains undissolved, after a day's exposure to a sufficient quantity of the acid, cannot be limestone.

Chemical analyses of soils, ores, mineral waters, etc., will be undertaken by the author of this treatise, and information given in regard to whatever is connected with the science. For particulars, address James Hyatt, care of John Wilkinson, Germantown, Pa.

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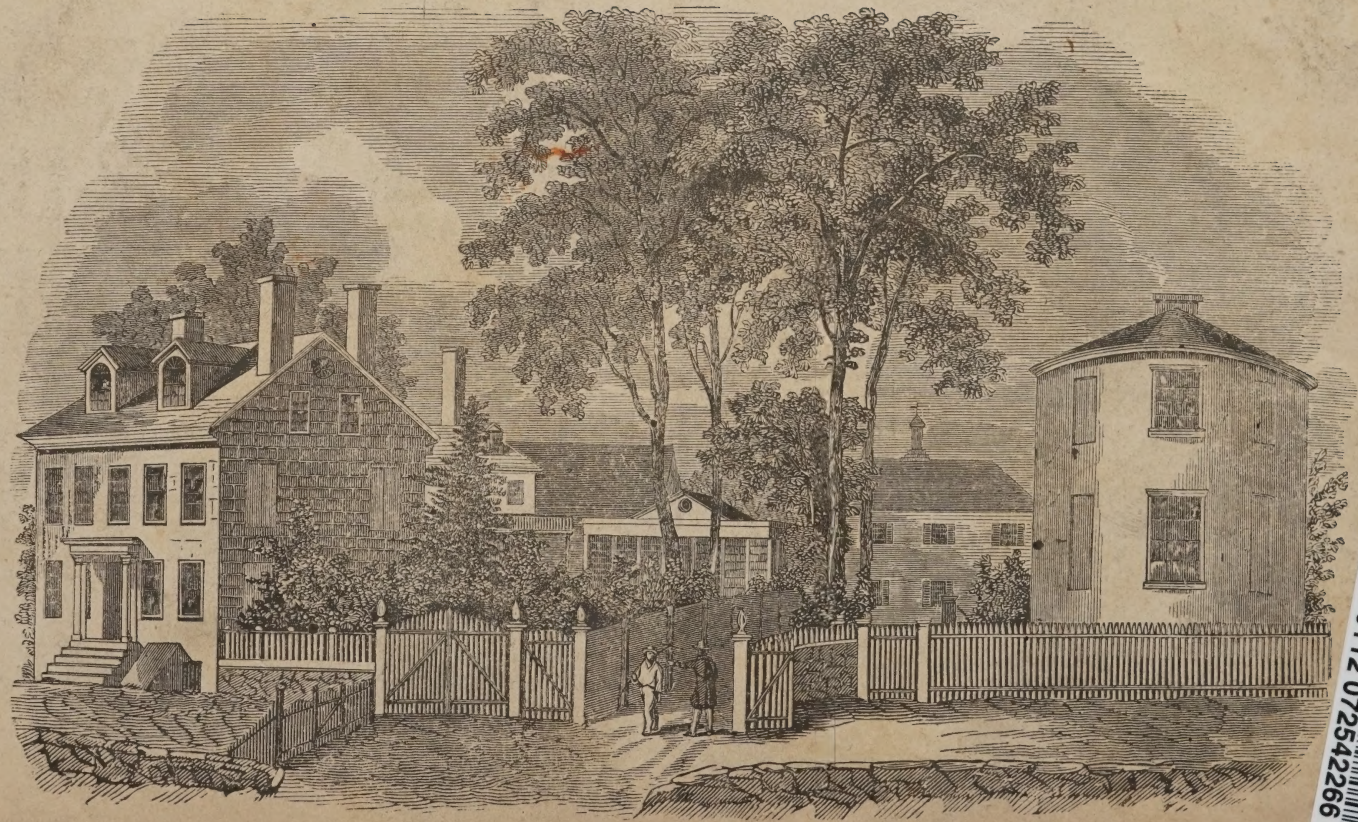

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